

Information Criteria and Approximate Bayesian Computing for Agent-based Modelling in Ecology: New Tools to Infer on Individual-level Processes

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Keywords: individual-based models; multi-model inference; animal behaviour.

Agent- or individual-based models (ABMs) are computer simulation tools to represent complex systems where the unique autonomous individuals constituting the system interact, adapt or evolve. In ecology, ABMs have been applied to analyse the influence of individual variability, spatial interactions, development, behaviour, learning or genetic variability on group, population or community dynamics [1]. During the last 20 years, the approach of pattern-oriented modelling (POM) has been helping in making the use of ABMs more robust and reliable [2]. Two main elements of POM are a) “inverse modelling” to reduce parameter uncertainty and b) “strong inferences” to test how well alternative model versions changing in certain individual-level processes are at explaining multiple patterns observed at the population and/or community level. The latter has many parallels to model selection procedures in statistical modelling (“multimodel inference” [3]). The inverse modelling borrows also concept and tools from statistics to fit unknown or uncertain parameters to real-world data. With the development of approximate Bayesian computing (ABC) in ecology [4] some propositions were made to use ABC in ABMs [5]. Bridging the two main elements of POM, an information criterion was proposed [6] that borrows concept of ABC such as Markov Chains Monte Carlo simulations without likelihood functions and multimodel inference in Bayesian context. This criterion (POMIC for pattern-oriented modelling information criterion) was applied in the original proposition paper to forest growth simulations to infer on individual tree growth function. Recently, it was applied to locust to infer on individual behaviour at hatching [7]. These kinds of cryptic processes (tree individual growth or animals’ behaviour during first hours) can typically be analysed following few isolated individuals in natural or experimental conditions. However, in the context of inter-individual interactions, experimental designs to infer on how the interactions modify individual responses are hard, if not impossible to elaborate. Using population or

group level data to fit ABMs and infer on the potential individual process with different ABMs version is then a way of overpassing these problems. However, the question of ABMs complexity (essential in statistical model selection procedures) needs to be addressed. The POMIC proposition includes a complexity measure and makes it therefore an interesting tool to infer on cryptic individual-level processes of complex systems.

References

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